Selected Jellyfish Hot Spots Around the World

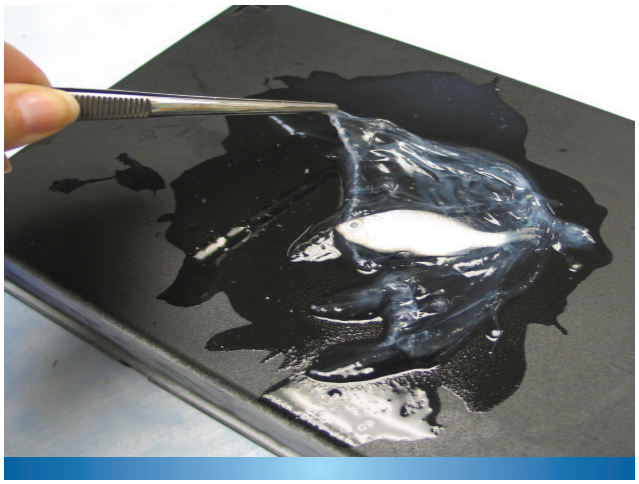
HAWAII

Stinging Outside of The Box

Water enthusiasts on Hawaii's Oahu Island are now literally "boxed-in" on the beach for several days each month--kept from the water by throngs of box jellyfish that pack powerful stings.

Recorded sightings of box jellyfish in Hawaii date back to the late 1880s. But no one knows if those earliest sightings mark the rise of an invasive population, possibly imported through shipping, or if they simply mark the first times that native populations of box jellyfish were noticed.

But whether or not box jellyfish are native to Hawaii, their numbers have dramatically increased during the last 20 to 30 years, says Dr. Angel Yanagihara of the University of Hawaii at Manoa, who has been systematically studying their numbers for the past 12 years. Even 30 years ago, swimmers did not encounter swarms of box jellyfish along Waikiki beaches, she says.



Into the Belly of a Jelly: A fish is trapped inside a Hawaiian box jellyfish. *Credit: Angel Yanagihara of the University of Hawaii at Manoe.*

The main species of box jellyfish that is now common to Hawaii is known as *Carybdea alata*. Its bell reaches about 4 inches in length and two inches in width. "No deaths have been directly attributed to *Carybdea alata* in Hawaii," says Yanagihara. Nevertheless, a tangle with this tentacled creature can be downright traumatic; after swimming into a swarm of Box Jellyfish in Oahu years ago, Yanagihara needed emergency care and respiratory support.

But, if an attack by a swarm of ultra-venomous jellyfish could ever hurt so good, this one did for Yanagihara because it ignited in her a passionate determination to analyze the biology of this creature's potent but largely unstudied venom. She now runs a research program devoted to doing just that.

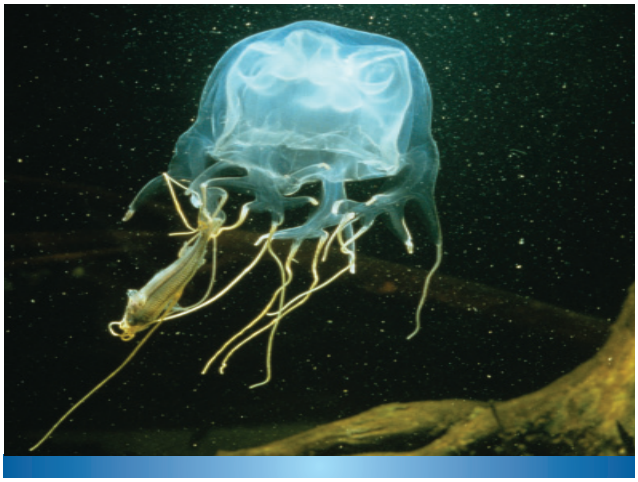
Unwelcome though the visits of box jellyfish are in Hawaii, they are at least predictable: eight to 12 days after each full moon, armadas of these invertebrates usually invade leeward beaches of Oahu. A typical armada of box jellyfish may number in the thousands and cause hundreds of stings.

No one knows why the box jellyfish of Hawaii follow the lunar cycle. But scientists suspect that their monthly beach swarms are in some way related to their spawning behavior.

Also mysterious is the cause of the increase in the size of Oahu's population of box jellyfish. However, Yanagihara suspects that it is a product of typical food chain disruptions involving decreases in predators and increases in food availability caused by human activities.

AUSTRALIA

The Expanding Range Of Potentially Deadly Irukandji Jellyfish



***Chironex Fleckeri,* The World's Most Venomous Animal**
Chironex means "the hand of death" in Latin and *fleckeri* honors Hugo Fleckeri, a jellyfish researcher. Equipped with up to 60 tentacles that can each reach about 20 feet in length, the bell of a *Chironex fleckeri* may reach the size of a basketball. One adult *Chironex fleckeri* has enough venom to kill 60 adults. *Credit: Courtesy of the Great Barrier Reef Marine Park Authority for and on behalf of the Commonwealth of Australia.*

There is a saying that "everything in Australia either bites or stings." This aphorism is supported by the behavior of many ornery Australian creatures--including the toxic toad, the venomous platypus, the fanged funnel web spider and various species of ultra-venomous snakes.

But Australia's reputation as an epicenter of freak animal assaults has recently been promoted particularly aggressively by what is described by Jamie Seymour of James Cook University in Australia as "an unprecedented occurrence of tiny jellyfish that cause Irukandji syndrome." Irukandji syndrome includes a range of intensely painful symptoms, including racking body pain, vomiting, skyrocketing blood pressure, high heart rate and sometimes even heart failure. The syndrome rates a "40" on a 1-to-10 pain scale, according to Seymour.

Irukandji syndrome is caused by at least six, and perhaps as many as 10, species of box jellyfish, which are among the most venomous creatures on Earth. Irukandji jellyfish range in size from the peanut-sized *Carukia barnesi* to fist-sized species.

IRUKANDJI JELLYFISH: VEXING ENVENOMATORS

Australia's unprecedented occurrence of Irukandji jellyfish has resulted in hundreds of hospitalizations since 2002 as well as the world's only confirmed deaths from Irukandji syndrome; two deaths spaced several months apart in Australia in 2002.

Irukandji syndrome is a particularly vexing problem because *Carukia barnesi*, as well as other species of jellyfish that are believed to cause the syndrome, are:

- **Tiny:** Some species of Irukandji jellyfish are small enough to slip through stinger-resistant beach enclosures in Australia that were designed to keep out the larger box jellyfish, *Chironex fleckeri.*

- **Unpredictable:** Irukandji jellyfish may strike in any of the coastal beaches, reefs and islands in the northern half of Australia, including the Great Barrier Reef. And, while stings from Irukandji jellyfish are most common from November through May, they have been recorded during every month of the year.

In other words, Irukandji syndrome--a torturous, potentially deadly syndrome--can strike virtually anywhere at any time in the waters of Northern Australia, which are frequented by millions of swimmers and divers annually. The only way that water enthusiasts in Northern Australia can totally prevent Irukandji syndrome is to stay out of the water.

WHY IRUKANDJI CASES ARE INCREASING

Seymour believes that increasing numbers of Irukandji stings are being recorded for two reasons:

1. Diagnosis and reporting of Irukandji syndrome has increased in the wake of the two Irukandji deaths in 2002.

2. The absolute numbers of Irukandji stings may be increasing. Why? Probably because of rising water temperatures, says Seymour. Here's how: As temperatures rise, southern waters that used to be too cold for Irukandji jellyfish may become part of their geographic range. In addition, rising temperatures may extend the summer season in the Irukandji's traditional habitat. A longer summer season translates into a longer jellyfish season.

Because Australia's waters are, for the most part, relatively unpolluted, Seymour does not believe that pollution is significantly contributing to the Irukandji problem.

CLIMATE CHANGE AND *CHIRONEX FLECKERI*

Australia is also home to *Chironex fleckeri*, which is the world's most venomous animal. For unknown reasons, the numbers of these animals in Australian waters varies considerably from year to year. But Seymour says that "there is currently no evidence that the numbers of *Chironex fleckeri* are, on the whole, increasing in Australia."

Seymour believes that increasing temperatures are unlikely to expand the ranges of *Chironex Fleckeri.* How come? Because this box jellyfish only lives in calm waters stilled by offshore reef systems. Therefore, despite rising temperatures, these animals are unlikely to move into environments that do not have reef systems.

Nevertheless, "more people appear to be stung by *Chironex fleckeri* in recent years compared to the past," says Seymour. But more people than ever before are swimming in Australia's waters. "More people unfortunately means more stings," says Seymour.

OTHER TYPES OF JELLYFISH IN AUSTRALIA

So far, at least two species of large box jellyfish and many species of smaller box jellyfish have been officially described in Australia. But scientists believe that Australia is also home to other species of box jellyfish that have not yet been official described.

Other jellyfish besides box jellyfish that live in Australia include the Lion's Mane and the Portuguese man-of-war. On average, about 10,000 stings from the Portuguese man-of-war are reported in Australia each year.

But in 2006, Australian beach-goers reported more than 30,000 stings from the Portuguese man-of-war--double the number reported the previous year. And in a single weekend in January 2007, Australian beach-goers suffered more than 1,200 stings, some of which required hospitalization. Scientists do not know whether these high numbers are merely flukes or reflect long-term increases in jellyfish populations.

THE MEDITERANEAN
Beach Bummer

Pelagia noctiluca–a pulsating purple jellyfish with an angry sting--has periodically bloomed in the Mediterranean for at least 200 years. But this species (which is also known as the mauve stinger) has traditionally followed a signature bloom-and-bust cycle: blooms have typically occurred about every 12 years--with each bloom followed by several consecutive summers of high jellyfish counts and then jellyfish-free summers.

But the summer of 2008 marks the eighth consecutive summer of jellyfish blooms in the Mediterranean. During some recent years, jellyfish have simultaneously swarmed in multiple Mediterranean locations in Italy, Spain, France and Greece and caused tens of thousands of stings requiring medical attention. As a prime tourist destination, the Mediterranean may serve as the ultimate test case of jellyfish tolerance by beach-goers.

A Vacation Buster: The numbers of mauve stinger jellyfish (centre-right) in the Mediterranean have increased as populations of fish that compete for food with jellyfish have decreased and ocean temperatures have risen. *Credit: Oceana*

CAUSES OF JELLYFISH INCREASES

Regarded as the cradle of civilization, the Mediterranean has been heavily exploited by people for thousands of years. But now, the chickens--or rather, the jellyfish--may finally be coming home to roost (and sting).
Scientists believe the Mediterranean's *Pelagia* populations are currently promoted by:

- Coastal development, pollution and over-fishing, which are wiping out jellyfish predators such as loggerhead turtles, and jellyfish competitors such as tuna, sardines and anchovies. In fact, many of the Mediterranean's commercial fish species are currently under threat of extinction.

- Increasing water temperatures, which may promote Pelagia reproduction.

- Relatively mild winters, which may enable *Pelagia* to survive the winters and thereby start the summer season at bloom strength. By contrast, when harsh winters cull *Pelagia* numbers, blooms are delayed until later in the summer. The ability of jellyfish to thrive throughout the winter in the Mediterranean was confirmed by the discovery of 30 blooms along the Spanish coast during the winter of 2007 to 2008; some of these blooms harbored up to 10 jellyfish per cubic meter of water.

DESPERATE TIMES, DESPERATE MEASURES

In August 2008, *The New York Times* reported that in a period of mere hours, 300 beach-goers in Barcelona were treated for stings and 11 required hospital treatment. Such statistics are compelling some popular Mediterranean resorts to take up arms against their tentacled invaders. For example, some popular beaches in Spain are now regularly swept by jellyfish-catching boats, similar to the way that hockey rinks are regularly swept by Zamboni machines. In addition, some beaches in Cannes, France are now surrounded by nets and booms to protect swimmers from jellyfish.

THE SEA OF JAPAN:
Nomurai Jellyfish: Proving that Size Matters

Giant Jellyfish In The Sea Of Japan: *Credit: Shin-ichi Uye, Hiroshima University*

China, which has produced some of the world's biggest ports, bridges, airport terminals and casinos, may also be producing some of the world's biggest jellyfish. During the summer of 2005, about 500 million *Nomurai* jellyfish--each weighing up to 450 pounds and bearing bells reaching almost seven feet in diameter--floated like bloated white balloons daily into the Sea of Japan; China is the suspected source of this bloom of super jellyfish.

MORE AND BIGGER BLOOMS

Other large blooms of large *Nomurai* have similarly occurred in the Sea of Japan every summer since 2000. But before 2000, only three blooms of *Nomurai* had ever been reported in Asian waters. What's more, these earlier blooms were smaller than recent blooms.

Why have *Nomurai* blooms apparently become more common and bigger? No one knows for sure. But current theories center on climate change, overfishing, water pollution, and the construction of structures along the Chinese coast that provide habitat for jellyfish larvae that attach to hard surfaces. In addition, the Three Gorges Dam on the Yangtze River, which is the world's largest dam, may be helping to change the chemistry of China's coastal waters in ways that favor jellyfish.

DAMAGE TO FISHING OPERATIONS

The recent *Nomurai* blooms have severely damaged fishing operations in Japan by 1) increasing capsizing risks for boats; 2) clogging and bursting nets; 3) reducing fish catches; 4) poisoning captured fish; 5) increasing labor needed to remove jellyfish from nets; and 6) producing stings to fishermen. Losses from *Nomurai* blooms to fishermen in just one Japanese prefecture have, thus far, totaled at least $20 million. (Problem *Nomurai* have been reported in at least 17 Japanese prefectures.)

If jellyfish establish permanent breeding populations in the Sea of Japan, they may bloom annually in these waters. A recent study concluded that such a change would be disastrous to fisheries but is likely to occur.

NAMIBIA
A Record-Breaking Bloom

The cool, nutrient rich waters off the coast of Namibia used to churn mostly with fish, such as anchovies and sardines. But now, they churn mostly with large jellyfish.

The increasing dominance of large jellyfish in the Namibian coast had been noted since the late 1990s. But a study completed by a team of British researchers in 2006 finally provided the first hard (but squishy) evidence of the rise of slime in the area.

According to results of the study, which included trawl surveys of Namibian waters, the Namibian bloom is extraordinary because of its:

- **Record-Breaking Mass:** The Namibian jellyfish bloom is among the largest blooms on record. The total weight of jellyfish in the region is about 12.2 million metric tons, which far exceeds the total weight of fish in the region, which is about 3.6 million metric tons.

- **Duration:** The Namibian bloom started in the late 1990s and has persisted more or less continuously since then. By contrast, most blooms vanish within several months.

- **Extent:** The Namibian bloom impacts over 30,000 nautical miles. In fact, if jellyfish were cobblestones, a person might be able to walk across this giant swarm by leaping from jellyfish to jellyfish.

IMPACTS OF BLOOM

Namibia's plague of jellyfish has wreaked havoc on the area's fishing industry, which used to harvest about 18 million tons of fish per year. In addition, by clogging vacuum tubes used in sea floor mining operations, Namibia's jellyfish have disrupted the mining of diamonds from the sea floor.

POSSIBLE CAUSES OF THE BLOOM

The researchers say that possible causes of the Namibian jellyfish bloom include climate change and intense harvesting of fish that compete with jellyfish for food; this may have increased the availability of food for jellyfish and thereby promoted increases in jellyfish populations.

Other researchers say that area currents, known for their strength, could have imported invading jellyfish along with food for them. Another possibility is that the ongoing bloom is part of a long-term natural boom-and-bust cycle of jellyfish populations that had never before been documented.

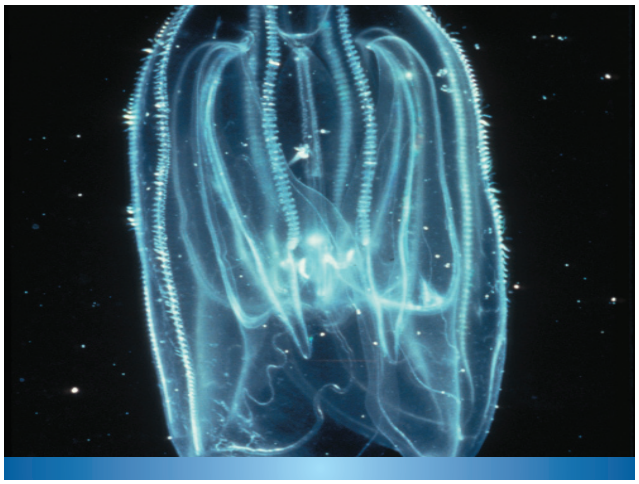
THE EAST COAST OF THE U.S.

A Voracious Predator Tightens its Tentacled Grip

Populations of the gluttonous, rapidly producing comb jelly called *Mnemiopsis* are increasing throughout the eastern seaboard. In addition, the northern border of this creature's range recently advanced from Cape Cod to Boston Harbor. These changes are probably at least partly caused by rising temperatures.

Increases in *Mnemiopsis* populations are disturbing because the belly of this jelly, which feeds continuously, is virtually bottomless. Driven by an insatiable appetite, large swarms of fist-sized *Mnemiopsis* jellies can almost literally eat a whole in the ocean.

Among the east coast waters that are supporting increasing populations of *Mnemiopsis* are Narragansett Bay and Chesapeake Bay. In addition, Invasive comb jellies, which originated on the East Coast of the United States, are now proliferating in European seas. (See "The Black Sea.")



A Brainless, Spineless Predator: Though humble in appearance, the fist-sized comb jelly *(Mnemiopsis)* is a voracious predator that dominates many ecosystems during the summer. *Credit: Laurence Madin, Woods Hole Oceanographic Institution*

NARRAGANSETT BAY

Since 1971, Narragansett's population of comb jellies has at least doubled; during their annual peaks, comb jellies are now a dominating force on Narragansett's ecology.

Narragansett's comb jelly explosion correlates with an increase of almost two degrees centigrade in average winter temperatures since 1950. This warming enables some comb jelly clusters to, as never before, survive the winter and start breeding and accumulating large populations in the spring. By contrast, comb jellies used to take until mid-summer to do so. A longer comb jelly season means more comb jellies.

In addition, Narragansett's comb jellies used to bloom too late in the summer to exploit blooms of small crustaceans, called copepods, which bloom in the spring; but now that comb jellies also bloom in the spring, they can consume large volumes of copepods. Because copepods are also eaten by fish, whales and sea birds, the impacts of their increased consumption by comb jellies may cascade throughout the food chain.

THE CHESAPEAKE BAY

No one knows how abundant gelatinous creatures were in the Chesapeake Bay before humans began impacting this heavily polluted water body. But the Chesapeake currently harbors large populations of many types of gelatinous creatures, including comb jellies, that are locked in a perpetual power struggle with large populations of comb jelly-eating sea nettles. Ecological dominance in the Chesapeake frequently swings back and forth between these two types of gelatinous creatures.

Currently, comb jellies wield the upper hand (or upper tentacle) in their power struggle with sea nettles. Why? One theory is that ongoing climate change produces conditions that are more favorable to highly adaptable comb jellies than to sea nettles, which have more rigid environmental requirements. Another theory is that the harvesting of the Chesapeake's oysters by the fishing industry has reduced habitat for juvenile sea nettles, which cling to hard surfaces --including oyster shells--and thereby helped reduce the Chesapeake's population of sea nettles. (By contrast, young comb jellies swim freely without clinging to hard surfaces.)

Continued dominance of the Chesapeake by comb jellies may damage its fish populations. Why? Because comb jellies eat more of the same foods that are eaten by fish and eat more fish eggs than do sea nettles.

EUROPEAN SEAS

Invasive comb jellies, which originated on the East Coast of the United States, are now proliferating in European seas. (See "the Black Sea.")

THE GULF OF MEXICO

The Biggest Dead Zone in the Western Hemisphere

Jelly Jam: In the Gulf of Mexico's densest jellyfish swarms, there are more jellyfish than there is water. 100 or more jellyfish may jam each cubic meter of water. Scientists are currently poring over records of worldwide marine life that were fastidiously maintained by some early explorers. Such analyses will help scientists better define how and where human activities are promoting jellyfish swarms. *Credit: Monty Graham*

The white sands and sparkling emerald waters of the Gulf of Mexico's beaches belie a dirty little (open) secret: a huge Dead Zone that is devoid of almost all life except jellyfish is expanding in the Gulf of Mexico. During the summer of 2008, the Gulf's Dead Zone covered about 8,000 square miles, about the size of Massachusetts. It is expected to soon reach about 10,000 square miles.

CREATION OF THE DEAD ZONE

The Gulf's Dead Zone is produced every summer by tons of fertilizer, sewage and animal wastes that are continuously dumped into coastal waters by the Mississippi and Atchafalaya Rivers. These pollutants do their dirty work by fertilizing huge algae blooms that decay through a process that robs Gulf waters of oxygen. Most sea creatures flee or suffocate to death in the Dead Zone's oxygen-starved waters, leaving highly adaptable jellyfish to proliferate unrestrained by predators and competitors and to gorge on the Gulf's bounty of plankton.

GROWING JELLYFISH POPULATIONS

The most abundant species of jellyfish in the Gulf are the sea nettle and moon jellyfish, which typically swarm over hundreds and perhaps even thousands of square miles each summer. Studies show that these species became significantly more abundant and expanded their ranges during the 1980s and 1990s. Moreover, since 2000, the Gulf has hosted invasions of several non-native jellyfish species, including the Australian jellyfish.

Signs that the Australian jellyfish is satisfied with its adopted Gulf home include its tendency to swell from its usual fist-size to the size of dinner plates in the Gulf. In addition, the Gulf's population of Australian jellyfish is steadily growing and expanding its range; this species recently reached North Carolina.

OTHER JELLYFISH-FRIENDLY FACTORS

Other factors besides the Dead Zone that probably encourage Gulf jellyfish to proliferate include:

- The creation in the Gulf of artificial habitat for young jellyfish (called polyps) that cling to hard surfaces by the presence of about 6,000 oil and gas production platforms and artificial reefs that are designed to support fishing. These artificial reefs are composed of at least one discarded bridge, a submerged aircraft carrier and acres of shopping carts, vehicles and other junk.

- The over-harvesting of fish that compete with jellyfish for food.

- The importation of invasive species of jellyfish into the Gulf by currents from the Caribbean and ships that provide hard surfaces to which young jellyfish cling.

GLOOM FROM BLOOMS

The Gulf's growing Dead Zone intermittently shuts down the Gulf's important shrimp industry: shrimpers do not even dare venture into the Gulf for dozens of days during typical swarm seasons because jellyfish masses would break their nets and clog their engines beyond repair.

Just the invasion of the Australian jellyfish alone cost the shrimp industry about $10 million dollars in 2000--not even counting the indirect costs of the consumption of eggs and larvae of commercial fish by these invading jellyfish.

GREAT BRITAIN, NORTHERN IRELAND AND IRELAND

Marauding Mobs of Jellyfish Decimate Fish Farms

In November 2007, a locust-like mob of billions of jellyfish covering 10 square miles to a depth of 35 feet bore down on a Salmon farm in Glenarm Bay in Northern Ireland. The mob was comprised of mauve stingers (*Pelagia noctiluca*), which are commonly found in the warmer waters of the Mediterranean but are a rarity in British waters.

As rescuers in boats unsuccessfully struggled to ply through the impenetrable pack of attacking jellyfish in time to save the salmon harvest, the mauve stingers slipped through the farm's underwater cages. The marauding mauves then smothered and stung to death every last one of the farm's 120,000 salmon, which were worth a total of about $2 million. After the attack, the fish farm's managing director lamented to BBC News, "The sea was red with these jellyfish and there was nothing we could about it, absolutely nothing."

The Mauve Stinger: In 2007 a mob of mauve stingers wiped out an entire salmon farm in Northern Ireland. *Credit: Alberto Roseo, romeo fotosubteam*

Several days after the Glenarm Bay massacre and a few miles down the coast from it, a rampaging raft of jellyfish killed more than 150,000 caged young salmon. Soon after, huge swarms of baby jellyfish were sighted in Scottish waters.

While describing the November 2007 damage to farmed fish from jellyfish as "unprecedented," the Natural Environment Research Council of England kicked off an urgent investigation into jellyfish ecology and possible impacts of climate change on jellyfish populations in January 2008. Designed to generate information to help prevent similar damage in the future, the investigation includes surveys, counts and health assessments of mauve stingers in the Irish Sea and North Atlantic.

This study is not the first to address jellyfish swarms in Great Britain, Northern Ireland and Ireland. In a study completed in 2007, British researchers documented increases in jellyfish populations in the North Sea since the mid-1980s. They also anticipated additional increases in the North Sea's jellyfish populations as climate change increases the temperature and acidity of these waters--conditions that are expected to benefit jellyfish.

THE BLACK SEA

Europe's Most Polluted Ocean Becomes the World's Jellyfish Capital

Death By Jellycide: The comb jelly known as *Beroe* eats other species of comb jellies. By doing so, it has helped control population explosions of comb jellies in various worldwide locations.
Credit: Casey Dunn

If the world had an official jellyfish capital, it would surely be the Black Sea--a huge inland sea located between Europe and Asia. Why? Because the Black Sea was transformed into a veritable jellytorium during the 1990s by an invasion of *Mnemiopsis*, a voracious, rapidly-reproducing species of comb jelly.

At its most jellified state during the late 1990s, the Black Sea harbored more than one billion tons of *Mnemiopsis*--which equals more than 10 times the weight of all fish caught throughout the world annually. In some parts of the Black Sea, each cubic meter of water–a space comparable to the interior of a large garbage bag–teemed with thousands of the golf ball-sized jellies.

The domination of *Mnemiopsis* over the Black Sea started in 1982--probably when a U.S. ship jettisoned into this sea ballast water from the U.S., along with some hitchhiking *Mnemiopsis*. This comb jelly is a hardy ecological squatter that is rapidly spreading along the east coast of the U.S. but had previously never visited the Black Sea.

Nevertheless, the Black Sea, Europe's most polluted ocean, provided a particularly hospitable environment to the *Mnemiopsis* newcomer. Why? Because the Black Sea has no natural predators of *Mnemiopsis* and because its overfished waters offered *Mnemiopsis* only minimal competition from fish. Feasting on copious quantities of plankton and able to shed 8,000 eggs daily, *Mnemiopsis* reproduced with wild abandon.

Swarming from coast to coast, *Mnemiopsis* crowded out almost all fish in the Black Sea. The result: losses of hundreds of millions of dollars to the area's fishing and tourism industries.

The tide only turned on *Mnemiopsis* in 1997, when another invading species of comb jelly, called *Beroe*, arrived in the Black Sea, probably also via ballast water from the U.S. Because *Beroe* eats *Mnemiopsis*, it has helped tame the Black Sea's *Mnemiopsis* monster.

Moreover, because *Beroe* eats nothing but *Mnemiopsis* and disappears as *Mnemiopsis* disappears, it has improved its adopted habitat without causing ecological problems--a rarity for an introduced species.

Nevertheless, *Mnemiopsis* remains a serious problem. Why? Because even though *Mnemiopsis* is controlled in the Black Sea through *Beroe*-assisted jellycide, it still greatly impacts area ecology. Additionally, *Mnemiopsis* has fanned out from the Black Sea via canals and ships to the Caspian, Azov and Mediterranean Seas. Also, additional waves of U.S.-based *Mnemiopsis* have recently invaded the North Sea and the Baltic Sea.

Just as it did in the Black Sea, *Mnemiopsis* has significantly reduced fish catches in many of these other huge seas. Indeed, *Mnemiopsis* has caused even more damage to fisheries in the Caspian Sea than it did in the Black Sea.

Some European nations have considered intentionally introducing *Beroe* into their *Mnemiopsis*-infested *w*aters. But so far, they have refrained from doing so for fear of unintended ecological consequences from such introductions. Moreover, it is uncertain whether *Mnemiopsis*-infested waters besides the Black Sea meet *Beroe's* requirements for salinity, temperature and other environmental conditions.

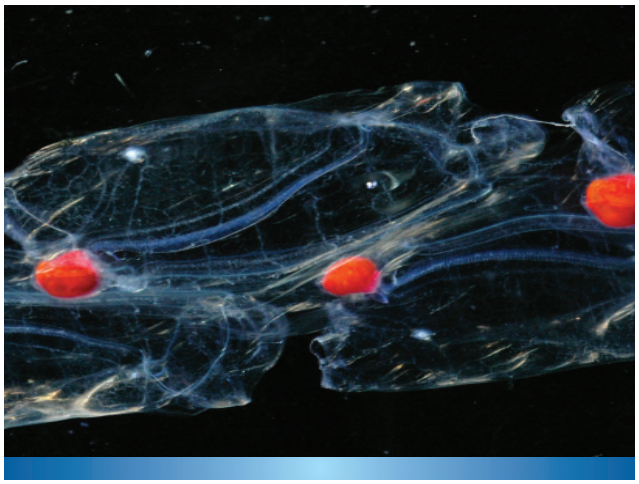
SALP SWARMS IN THE NEW YORK BIGHT AND SOUTHERN OCEAN

Will Salp Blooms Bring Gloom to Penguins and Whales?

Salps are transparent, tube-shaped gelatinous animals that live in every ocean. They can form huge swarms composed of billions or trillions of organisms that are each up to about three inches in length.

During four summers since 1975, Laurence Madin of Woods Hole Oceanographic Institution led research expeditions to the mid-Atlantic Bight, which extends from Cape Hatteras to Georges Bank. During each trip, Madin observed a salp swarm lasting months that covered up to 38,600 square miles (no – that is not a typo!); this area is comparable to the size of the state of Virginia.

Madin suspects that the salp swarms form in the mid-Atlantic Bight every summer, and are a natural phenomenon that is not significantly impacted by human activities. But he says that the swarm has not been studied enough to know for sure.



Gellatinous Animals Come in a Profusion of Sizes and Shapes: Salps are tube-shaped gelatinous animals. *Credit: Laurence Madin, Woods Hole Oceanographic Institution*

Information gaps about salps are due in part by their elusive nature: many species spend their days in the ocean's depths, only surfacing at night. "You probably wouldn't see salps unless you go where you expect them to be and specifically look for them at night," says Madin.

Another important ecosystem for salps is the Southern Ocean near Antarctica. Salps of the Southern Ocean eat tiny, plant-like organisms called zooplankton, which are also eaten by krill.

Studies show that over the last 80 years, the size of the Southern Ocean's salp population has increased while its krill population has decreased. These changes could be caused by reductions in sea ice that--in turn--have been caused by increasing temperatures. Reductions in sea ice may favor salps because they swim and feed in open water; by contrast, krill feed on organisms growing under the ice.

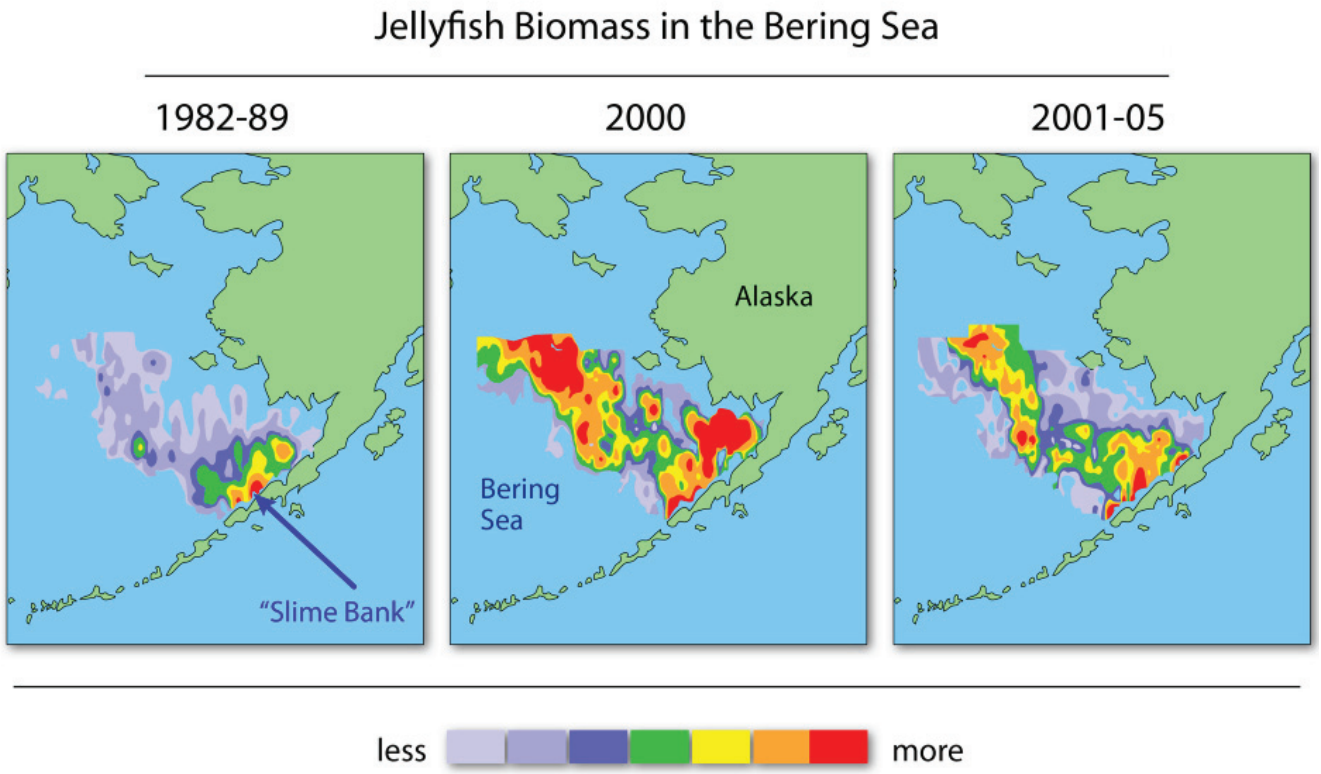
Reductions in the Southern Ocean's krill population could cause food shortages for krill-eating predators, such as penguins and whales.

THE BERING SEA

Home to "The Slime Bank"

Nicknamed "America's Bread Basket," the Bering Sea produces more than fifty percent of the U.S.'s entire catch of fish and shellfish. But now the long tentacles of environmental change are wrapping around this important fishery.

How? By expanding the range and increasing the size of the Bering Sea's jellyfish population. The problem? Jellyfish compete for plankton food with pollock, an important commercial fish, and may consume young Pollock.



After peaking in 2000, jellyfish populations have moderated at levels that still exceed those of the 1980s. Also, jellyfish ranges have expanded. Credit: *Zina Deretsky, National Science Foundation, after Brodeur et al in "Progress in Oceanography"*

THE RISE AND FALL OF BERING SEA JELLYFISH

Starting in the 1990s:

- Bering Sea jellyfish began fanning out north and west from the Alaskan Peninsula. "We began finding thick concentrations of jellyfish in places where we had hardly seen jellyfish before," says Lorenzo Ciannelli of Oregon State University.

- The size of the jellyfish population in the eastern Bering Sea soared by ten-fold, eventually peaking at record levels in about 2000.

During this period, one area north of the southeastern Alaskan Peninsula became so jellified that fishermen nicknamed it "the Slime Bank" and began avoiding it altogether for fear of tangling their nets in wads of tentacles.

After 2000, the Bering Sea's jellyfish population downsized, eventually stabilizing at moderate levels that still exceed the relatively low numbers of the 1980s.

THE CAUSES OF JELLIFICATION

Scientists suspect that many factors are influencing the ups and downs of the Bering Sea's jellyfish population. For example, the annual harvesting of more than one million tons of pollock may increase the availability of plankton food for jellyfish.

In addition, sea temperatures, which have increased since 1990, may be promoting jellyfish reproduction and expanding jellyfish ranges northward. Nevertheless, because temperatures continued to climb as jellyfish populations declined after 2000, scientists believe that--no matter how much temperatures rise--there may be a finite number of jellyfish that the Bering Sea can support.

AN ALL-POINTS-BULLETIN FOR POLYPS

Ciannelli suspects that jellyfish expand their ranges by colonizing new areas as polyps--a developmental phase during which they live as tiny transparent organisms clinging to the ocean floor. But no one knows where the Bering Sea's elusive polyp colonies are located.

Ciannelli's research team is currently attempting to find them via computer simulations that recreate the release and drifting of young jellyfish from suspected polyp habitats. These analyses are designed to help scientists identify the locations of cyber polyp colonies that seed cyber swarms resembling real-life jellyfish swarms. Then, the real-life locations of these cyber polyp colonies can be studied further, perhaps eventually by undersea robots. "To really understand the Bering Sea's jellyfish, we just have to find those polyps," Ciannelli says.

Ciannelli's research team includes Mary Beth Decker of Yale University, Kung-Sik Chan of the University of Iowa and Carol Ladd of the National Oceanic and Atmospheric Administration.

PALAU'S JELLYFISH

Evolution in the Fast Lane

Chockfull of millions of Golden Mastigias jellyfish, Jellyfish Lake is a 12-acre marine lake located in the Republic of Palau, an island nation in the Pacific Ocean that is about 500 miles east of the Philippines. The lake, which sits in a limestone depression, formed and filled with jellyfish about 12,000 years ago after the last ice age ended and sea level rose; rising waters swept jellyfish into the lake before it became landlocked.

Landlocked Jellyfish: The jellyfish of Palau.
Credit: Michael Dawson, University of California, Merced

JELLYFISH LAKE LOSES ITS JELLYFISH

Reflecting the sensitivity of some species of jellyfish to temperature changes, Jellyfish Lake's population of Mastigias suddenly crashed in the late 1990s–apparently because of increases in water temperature caused by the El Niño of 1997 to 1998. During this post-El Niño period, Jellyfish Lake did not have a single adult jellyfish to justify its name.

But demonstrating the resilience of a multi-stage lifestyle, Mastigias polyps--which are more heat tolerant than adult Mastigias--had apparently survived the warm period; they eventually supplied new generations of Mastigias. By 2001, Jellyfish Lake was again pulsating with millions of Mastigias.

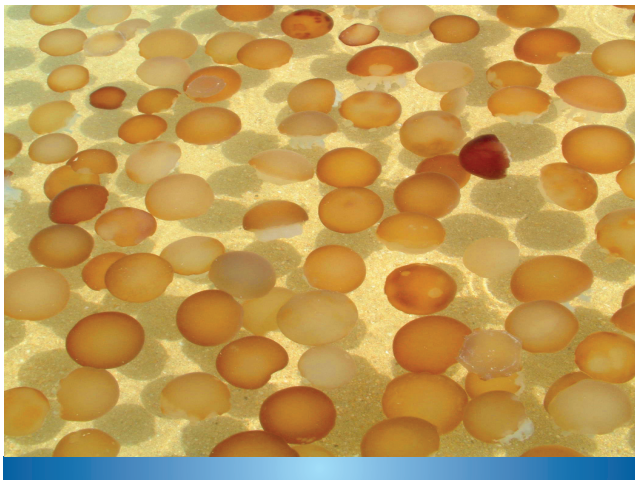
LANDLOCKED JELLYFISH

Living in a landlocked lake, the jellyfish of Jellyfish Lake have, since their initial arrival in the lake, evolved without genetically mixing with other jellyfish populations, similar to the way that species of animals that live on islands may evolve in isolation. These jellyfish are also evolving particularly quickly--as reflected in an unusual level of variation in the appearances of individual members of this population.

Michael Dawson of the University of California at Merced, is currently studying the genetics of the Mastigias of Jellyfish Lake. By producing insights into the evolutionary adaptations of these jellyfish, his research may help explain how invasive jellyfish species quickly adapt to new environments.

THE GULF OF OMAN AND PERSIAN GULF

A Huge but Natural Bloom



Invasion of the Invertebrates: Huge numbers of dead and dying jellyfish *(Crambionella orsini)* wash up in the shallows at Bandar Jissah, near Muscat in Oman. In 2002, this species proliferated in huge numbers, causing problems for fishermen and even fouling the water intakes of boats and power stations. *Credit: Fergus Kennedy, Indian Ocean Research and Conservation Association*

From 2002 to 2003, jellyfish bloomed over hundreds of miles of coastline in the Gulf of Oman and the Persian Gulf. So dense were these blooms with jellyfish that some bottom trawls targeting groundfish returned catches that were comprised of up to 90 percent jellyfish. Damage to fishing operations, desalination plants and coastal power plants resulted.

To identify which jellyfish species populated the bloom and the bloom's cause, a research duo composed of Michael Dawson of the University of California, Merced, and Iranian fisheries expert Reza Daryanbard poured over data on the size and density of the bloom provided by local fishing operations; and analyzed the genetics of the blooming jellyfish. Their results characterize the bloom as a natural phenomenon that was probably not triggered by local, man-made environmental problems.

How can scientists distinguish a natural from an abnormal bloom? In this case, the researchers developed their diagnosis via a process of elimination. They were largely were able to eliminate most man-made causes based on the following bloom characteristics:

- **The bloom's composition:** The researchers identified the blooming jellyfish as a species that occurs naturally in the nearby western Indian Ocean and adjacent basins. Therefore, the bloom was apparently not caused by the introduction of non-native species of jellyfish.

- **The bloom's extent**: Because the bloom was geographically widespread over non-coastal areas, the researchers concluded that it probably wasn't caused by the influx of pollutants from coastal rivers or other causes common to environmentally degraded coasts.

- **Water temperatures:** During the bloom, water temperatures remained moderate without showing extremes. Moreover, the researchers found no evidence for long-term changes in water temperatures in the bloom region. Therefore, they concluded that the bloom was probably not caused by climate change.

Nevertheless, Dawson says that "due to limited data, we cannot exclude the possibility that human ecological disturbances, such as commercial fishing, may have contributed to the bloom; nor can we exclude panoply of possible natural causes."